JPL's First Payload Development Experiences for the M-Cubed/COVE CubeSat Flight Experiment

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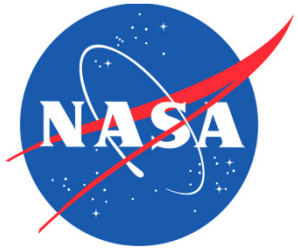


September 7, 2010
CubeSat/SmallSat Technical Interchange with The JPL Innovation Foundry

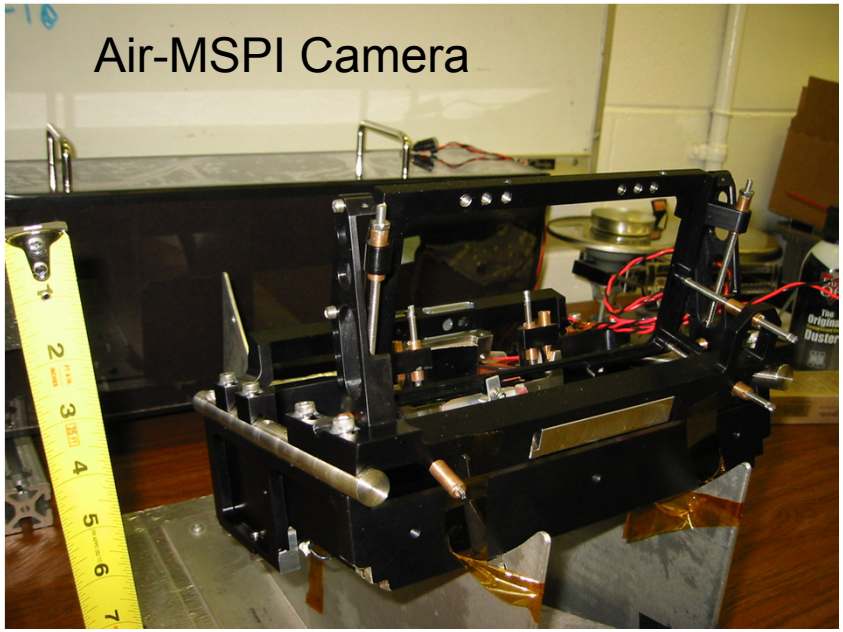
Outline

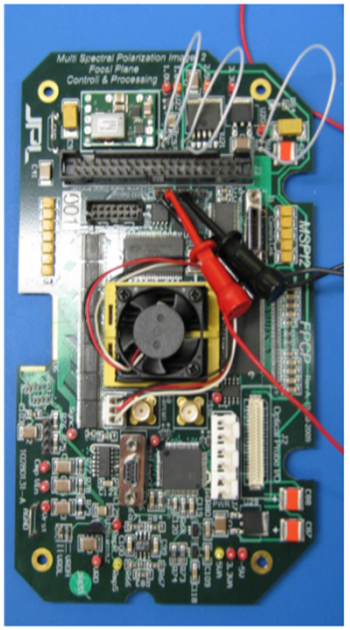
- Motivation for COVE
- JPL/U. Michigan Collaboration
- COVE Payload: High-Level Block Diagram
- COVE Board Development
- Final Stages
- Payload Development Experiences
- Summary
- Acknowledgements

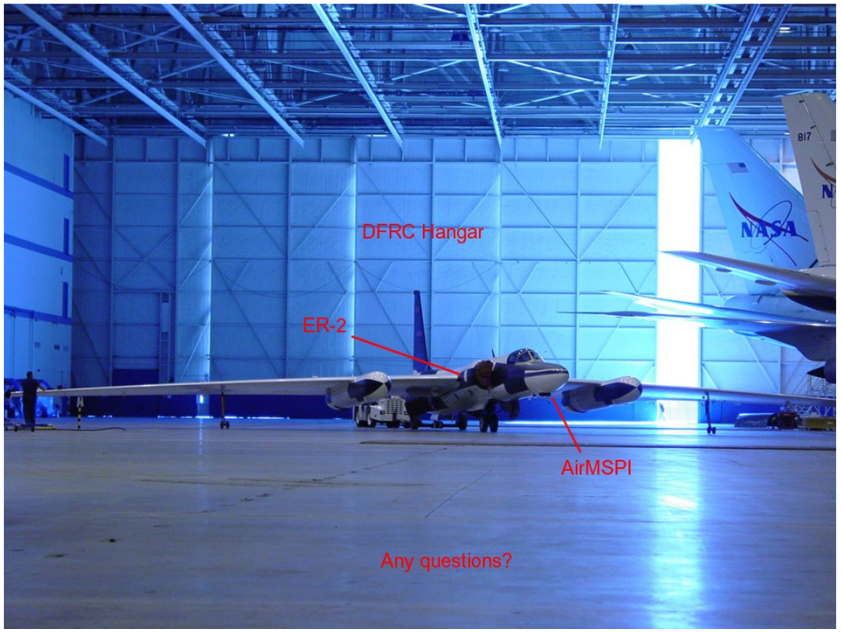
Motivation for COVE

MSPI: Multi-angle SpectroPolarimetric Imager

- Measures cloud and aerosol properties
- 8-fixed and 1-gimballed cameras, each with 16 channels
- A single MSPI camera must process 95 Mbytes/sec of raw video data; data reduction to 0.45 Mbytes/sec is required





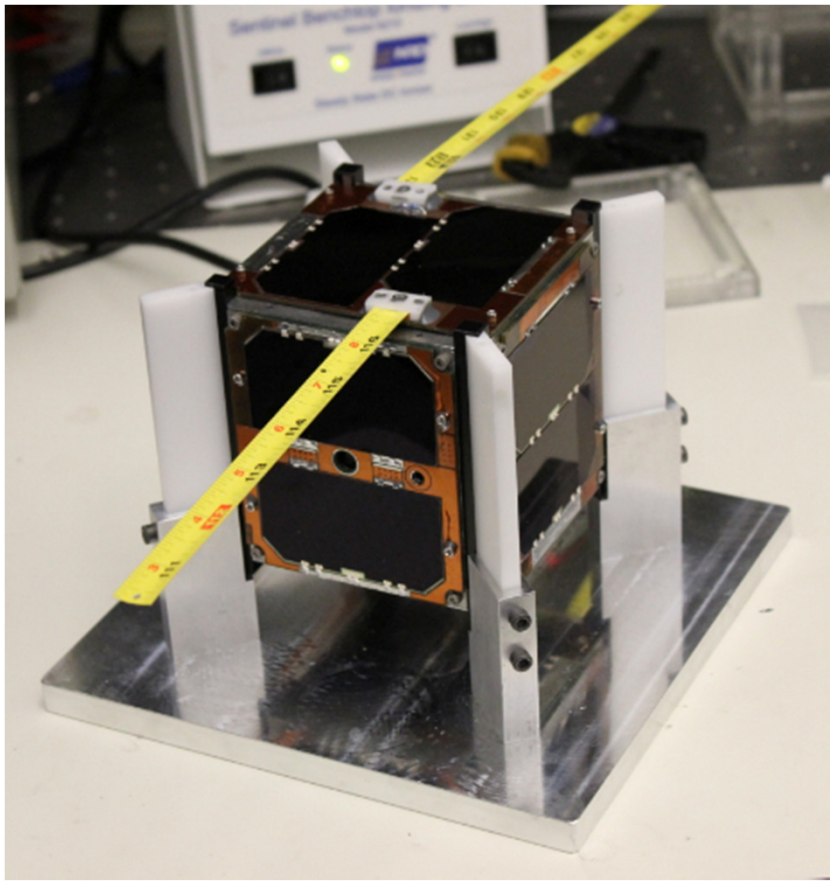


The information technology processing challenge is to apply on-board processing to extract intensity and polarimetric parameters from the real-time data stream across each camera thereby reducing the data volume by 2-orders of magnitude without loss of science information.

JPL/U. Michigan Collaboration

M-Cubed/COVE OBJECTIVES:

- Raise TRL of ESTO Technologies relevant to the Earth Science Decadal Survey Missions
  - MSPI On-Board Processing (OBP) algorithm
  - Xilinx Virtex-5QV Single event Immune Reconfigurable FPGA (SIRF)
- Capture and downlink mid-resolution images of the Earth
- Educate and train the next generation of engineers in the Aerospace Industry

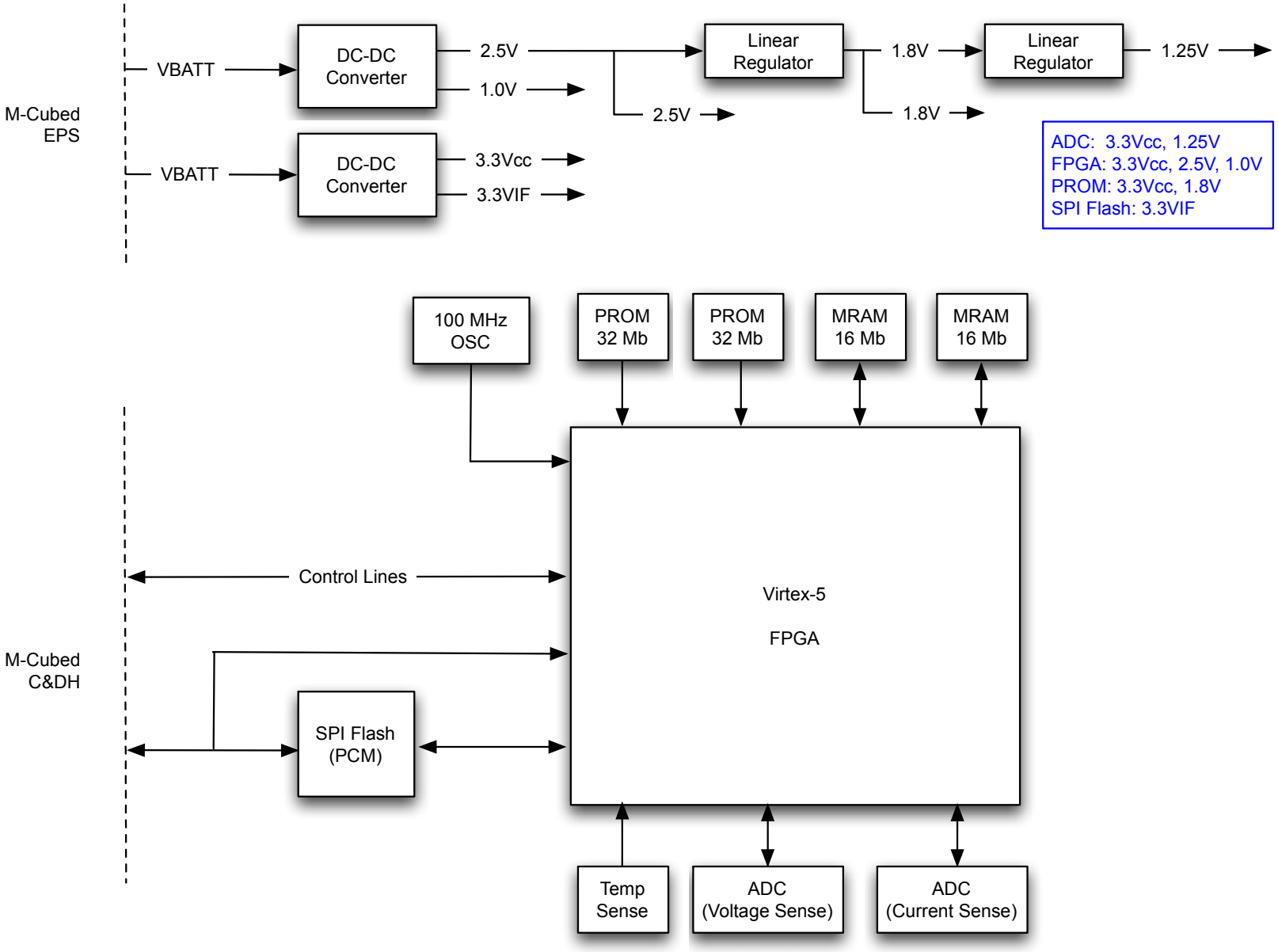


M-Cubed (Michigan Multipurpose MiniSat) Flight Model
Image Courtesy of U. Michigan

SmallSat platforms can rapidly advance the TRL of key instrument components and serve as platforms for new science observations

COVE Payload

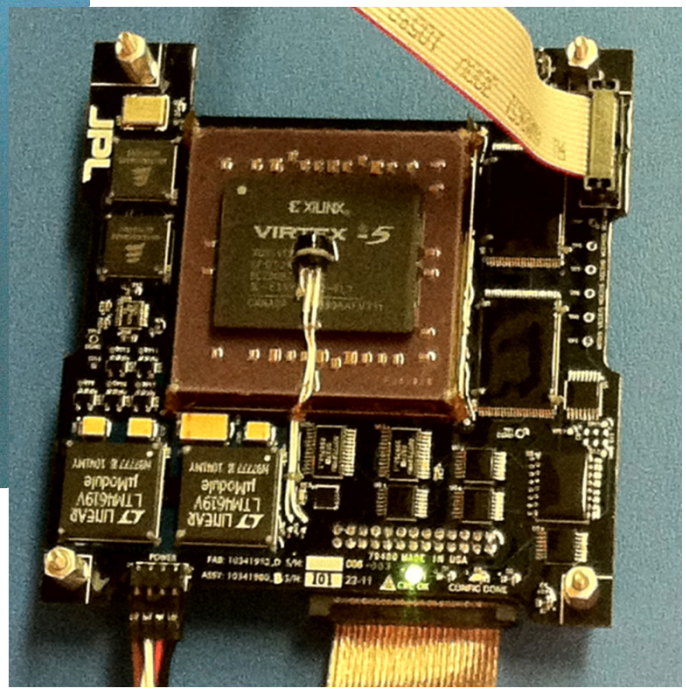
High-Level Block Diagram



COVE Board Development

Engineering Model
(Commercial Virtex-5)

Flight Model
(V5QV Production SIRF)



Flight Spare
(V5QV Engineering Sample SIRF)

Press Release: Xilinx Space-Grade Virtex-5QV FPGA in Production with Mega-Rad Capability (July 21, 2011)

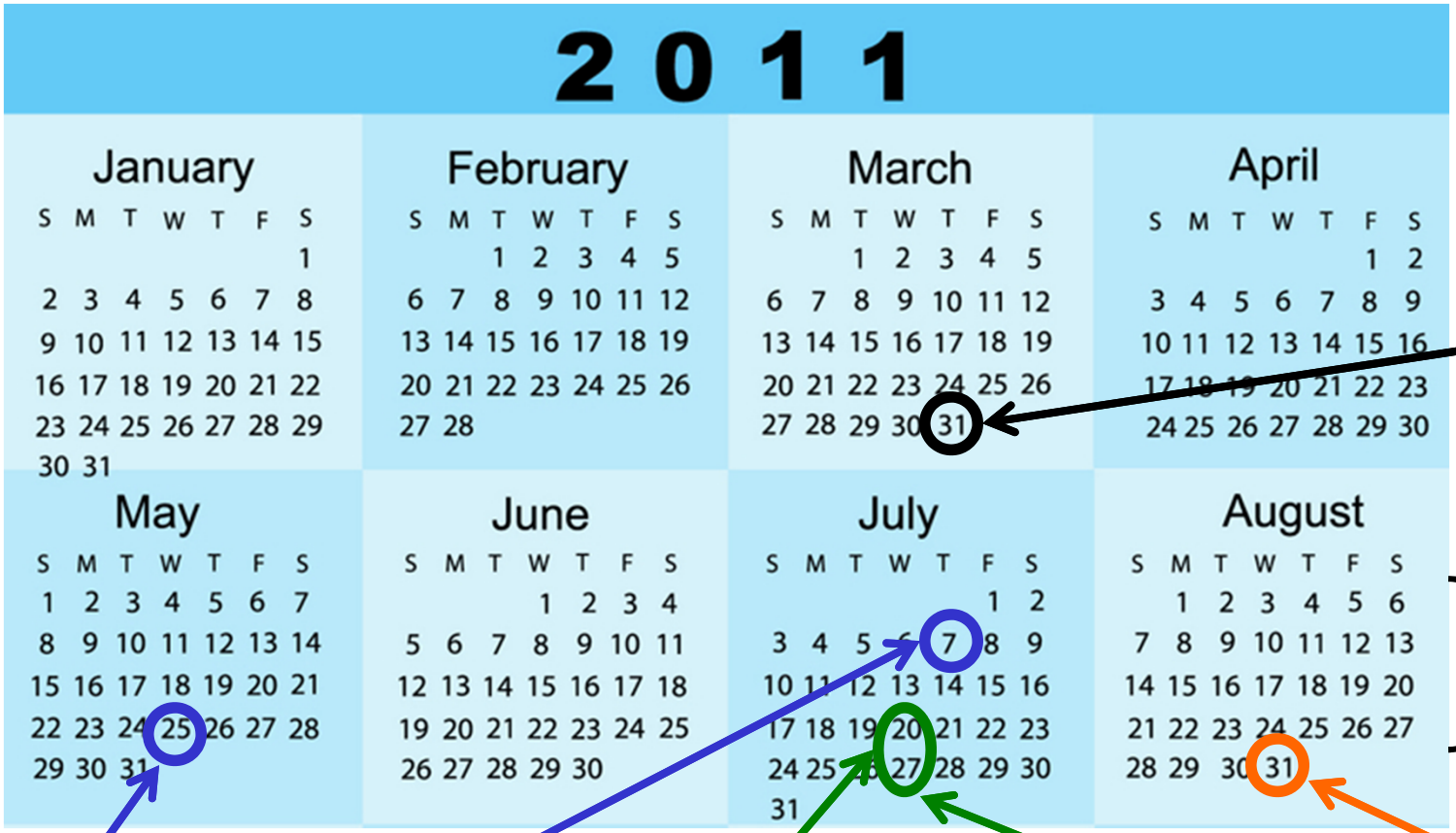
Final Stages

- ✓ COVE FM Payload (V5QV SIRF) delivered to U. Michigan, July 27
- ✓ M-Cubed/COVE Integration & Test Complete
  - ✓ Vibration, Thermal & Shock Tests Complete
  - ✓ Delivered to Cal Poly SLO for P-Pod Integration on Aug. 31
- Launch via NASA Space Operations Mission Directorate (SOMD) CubeSat Launch Initiative on ELaNa 3
  - NPP Mission (as a secondary payload)
  - VAFB on Oct. 25, 2011

COVE Payload Development Experiences

1. Xilinx V5QV SIRF Delivery
2. DC-DC Converter Component Failure
3. JPL Institutional Requirements for Flight Hardware
4. University of Michigan Partnership

COVE Payload Development Experiences
Xilinx V5QV SIRF Delivery



May 2010 - Task Start
-- Xilinx V5QV advertised available to order in Dec. 2010

3/31 – JPL/Xilinx face-to-face meeting

M-Cubed/COVE I&T (incl. vibe, thermal, shock)

5/25 – Xilinx Engineering Sample (ES) devices received

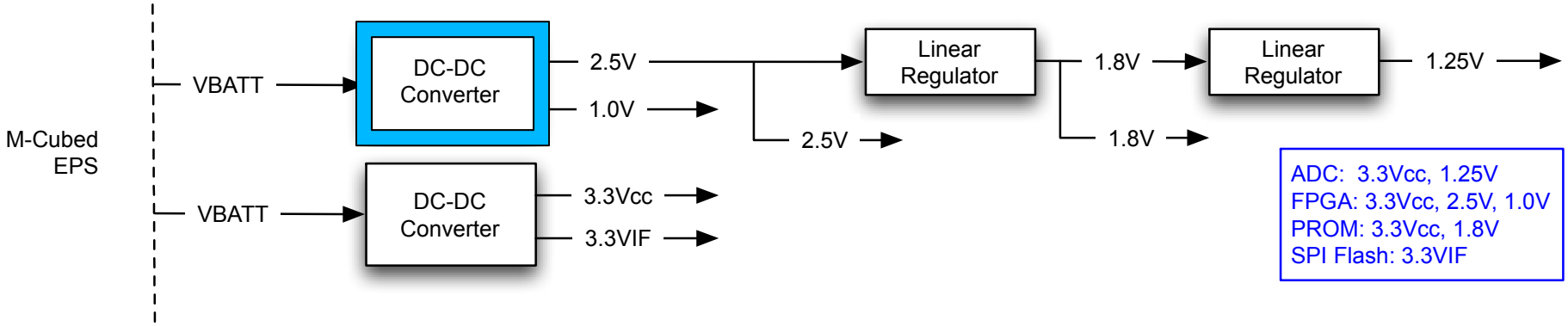
7/7 – JPL delivers COVE ES-1 Payload to UM; HRCR held 7/5

7/20 – Xilinx V5QV SIRF production device received

7/27 – JPL delivers COVE FM (SIRF) Payload to UM; HRCR held 7/26

M-Cubed/COVE delivered to CalPoly SLO for P-Pod integration

COVE Payload Development Experiences
DC-DC Component Failure



- LTM4619 DC-DC Converter: Commercial-grade, LGA
- Component DOA on first power check
- Component removed and replaced (heroic effort by 374 & 512)
- 5X investigating component failure

COVE Payload Development Experiences
Institutional Requirements

IOM-389F-PJP-11-001-D

To: Matt Landano (Director for Office of Safety and Mission Success)
Brian Muirhead (JPL Chief Engineer)
Chris Jones (Associate Director for Flight Projects and Mission Success)

From: Paula Pingree (COVE PI and 389F GS)

Date: June 2, 2011

Subject: Proposed COVE Implementation Approach to Address Institutional Requirements for Flight Hardware

This memo serves to document the proposed implementation plan to satisfy the intent of JPL institutional requirements in the areas of 1) Flight Project Practices (FPP), 2) Design Principles (DP), and 3) CoFR for COVE, the CubeSat On-board processing Validation Experiment.

- Memo documents institutional process agreement for COVE Task compliance to FPPs, DPs, CoFR
- PI worked with Safety & Mission Assurance (5X) to define content
- 8X is preparing a Task Implementation Plan (TIP) for CubeSat Technology Validation

Appendix A – COVE FPPs

FPP #	FPP Description	COVE Intent/ Implementation
5.7.2.1	Projects develop engineering models for new and significantly modified designs for mission-critical components.	COVE EM was developed.
5.10.2	Each project uses existing JPL and NASA information technology (IT) infrastructure (e.g., email systems, PDMS, electronic libraries, network architecture, computer and network security, access control) to satisfy its on-Lab needs and to provide the necessary interfaces with off-Lab systems.	COVE team uses IT infrastructure including email, PDMS, and http://fermi/trac repository.
6.4.2	Architectures (including physical, behavioral, operational (control), functional, data, etc.) are developed, captured and maintained as part of the design baseline in functional block diagrams, state diagrams, flow diagrams, configuration drawings, etc.	COVE Functional Block Diagram developed, captured, and maintained.
6.4.6	Interfaces between distinct elements of the system are defined, documented, controlled and their implementation verified. Interface documentation includes electrical, mechanical interface control documents / drawings, software interface specifications, and operational interface agreements.	ICD exists and is controlled between M-Cubed (UM) and COVE (JPL).

Appendix B - COVE Safety and Mission Assurance Requirements

- Comply with all applicable Safety Requirements- consult Kirk Barrow for details
- All parts (commercial-grade or military-grade, when available) ordered by COVE team require a Certificate of Compliance/Conformance (C of C).
- COVE board will be assembled by JPL flight certified technicians.
- Hardware QA will perform 3 inspections
  1. Test set-up in the lab
  2. Board workmanship after assembly and prior to first power on
  3. Board inspection following all tests and prior to delivery to UM
- AIDS and Test Procedures will be used to maintain pedigree.
- Developmental PFRs will be used with closure by CogE, PI, & Line Management.
- Consider performing an Interface FMECA if it adds value; no 5xx review required.

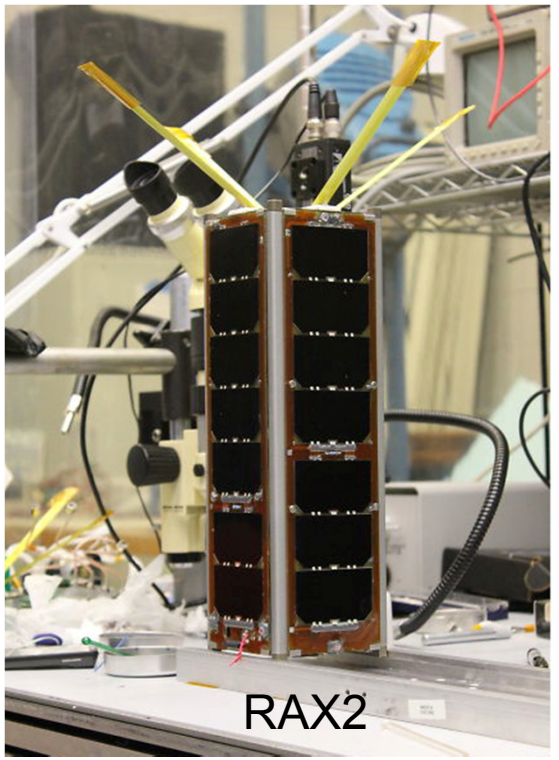
Appendix C – COVE DPs

DP#	DP Description	COVE Intent/ Implementation
4.1.1	**Safety** – All elements of the flight system shall adhere to the applicable design requirements of JPL Standard for System Safety (D-560)(JPL Rules! DocID 34880).	√ Comply
4.1.2	**Design Standards** – The flight system design shall adhere to all applicable standards adopted by JPL.	√ Comply

COVE Payload Development Experiences

U. Michigan Partnership

- Student CubeSat team mentored by Dr. Jamie Cutler (COVE Co-I)
- U. Michigan CubeSat experience
  - RAX (Radio Aurora eXplorer): 1st NSF-sponsored CubeSat, launched Nov. 19, 2010 from Kodiak Island, Alaska
  - RAX2 and M-Cubed are both secondary payloads on NPP launch
- Weekly M-Cubed team meetings with JPL telecon participation
- Collaborative development of the M-Cubed/COVE Interface Control Document (ICD)
- ESTO Interim (6-month) and Annual Reviews held at U. Michigan



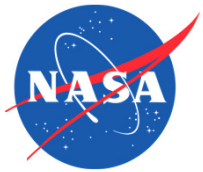
Summary

- JPL Participation
  - ESTO: Charles Norton
  - 389: Paula Pingree (PI), Thor Wilson (Co-I), Brian Franklin, Nooshin Meshkaty, Chris Peay
  - 388: Thomas Werne, Dmitriy Bekker
  - 374: Atul Mehta, Noly Neverida, Hung Truong
  - 512: Reza Ghaffarian, John Kennedy
- Schedule – 18 months *(from Task Start to Launch!)*
- Total Cost - $1.185M *(includes Launch cost and Mission Ops support)*

√ JPLs 1st CubeSat Payload to Launch

√ JPLs 1st installation of 1752-pin CCGA device

√ 1st Xilinx V5QV SIRF production part to fly



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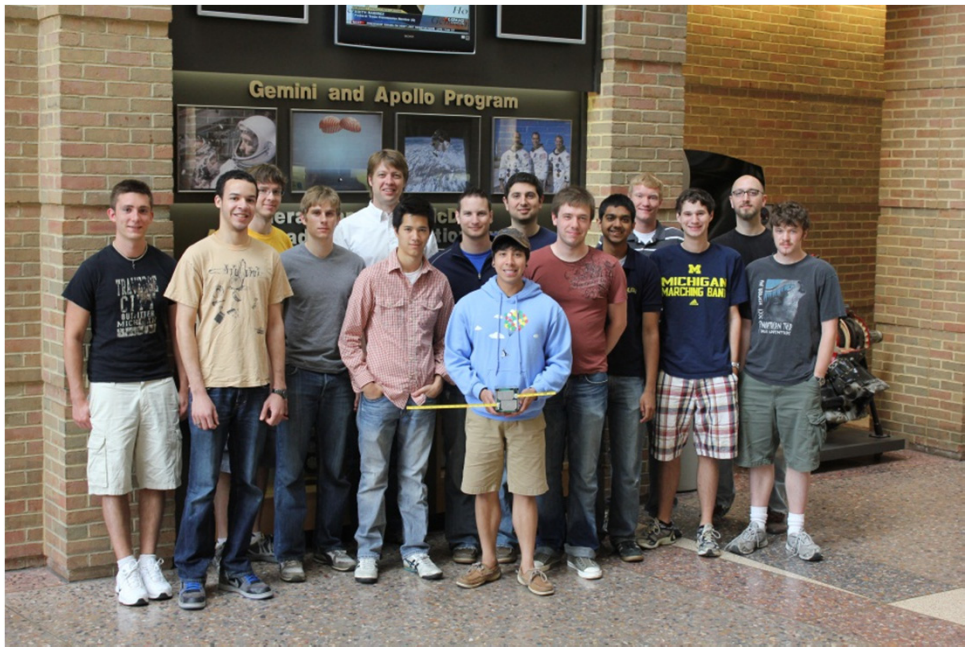
Acknowledgments

JPL COVE Payload Team

U. Michigan M-Cubed Team



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